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GLOBAL DEPLOYMENT ANALYSIS SYSTEM (GDAS) PHASE II
INDEPENDENT VERIFICATION AND VALIDATION MANAGEMENT PLAN

Prepared for:

U.S. Army Concepts Analysis Agency
Special Assistant for Model Validation (CSCA-MV)
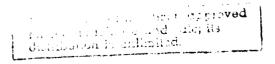8120 Woodmont Avenue
Bethesda, Maryland 20814-2797

Prepared by:

Potomac Systems Engineering, Inc.
7611 Little River Turnpike, Suite 600
Annandale, Virginia 22003

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Government Sponsor: U.S. Army Concepts Analysis Agency
Contractor's Project Director: Vernon M. Bettencourt
Contractor's Telephone: (703) 642-1000

28 June 1991

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EXECUTIVE SUMMARY

The primary objective of this Independent Verification and Validation (IV&V) effort is to help assure that development of the Global Deployment Analysis System (GDAS) results in a model that will perform as intended. This Independent Verification and Validation Management Plan (IVVMP) describes PSE's approach to the verification and validation of the model developer's efforts. It is a living document that is updated periodically to document GDAS program changes and updates. This is the final version of the GDAS Phase II IVVMP. GDAS Phase II IV&V activities have not required an update of the initial Phase II IVVMP delivered in July 1990.

Development of the GDAS is a 24-month project, executed in three phases. Phase I is complete. This IVVMP update addresses IV&V activities planned during phase II, a 12-month implementation phase during which the model developer was tasked to develop, document, and test all GDAS system functions. Phase III will follow with system integration, formal testing, and user training.

A sound IV&V program will ensure that the quality of the model software is established early in the development phase and that this level of quality is maintained and increased as the software is tested, transitioned to the users, and entered into the operations and support phase of the life cycle. It will also promote an efficient design, quality code development, complete functionality, realistic data requirements, run-time efficiencies, and effective human factors engineering.

Prepared by:

Vernon H. Hamilton
Director, CAA Programs

Approved by:

Wesley L. Hamm
CAA Program Manager

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SECTION 1. INTRODUCTION

1.1 Global Deployment Analysis System (GDAS) Overview

Development of the GDAS is the first step in developing an extensive automated
data processing (ADP) system that will evaluate the capabilities and
requirements of Department of Defense mobilization and deployment systems, and
will also provide input to combat models at the U.S. Army Concepts Analysis
Agency (CAA). CAA is a Field Operating Agency functioning under the
jurisdiction of the Director of the Army Staff. As part of its mission, CAA
must evaluate the Army's operational capability to mobilize; deploy forces;
and conduct unilateral, joint, and combined operations in various theaters of
operations. CAA uses computer models, simulations, and other ADP tools and
techniques to determine strategic mobility capabilities and requirements
supporting several Defense Guidance objectives.

CAA's Transportation Model (TRANSMO) has been the primary tool providing data
for deployment analyses. Over the past several years, the advent of the Force
Evaluation Model (FORCEM) as CAA's primary theater campaign simulation,
combined with requirements for such studies as the Ultra-Fast Sealift Study
(UFSS) and the Army Strategic Mobility System Assessment (ASMSA), have clearly
established the need for an improved deployment model.

In 1987, CAA conducted an internal study, the Transportation Evaluation
Research Project (TERP), which examined the overall CAA strategic mobility
process supporting a wide range of studies. TERP determined requirements for
the CAA transportation analytical process and examined various models as
possible alternatives to TRANSMO. None of the candidate models met all of
CAA's requirements, so a major TERP recommendation was that CAA pursue the
acquisition of a new model to simulate both inter-theater and intra-theater
transportation. The TERP further recommended that CAA initiate a formal
statement of requirements to be used as a basis for a statement of work for
system development.

The GDAS project addresses only the inter-theater transportation systems. Its
objective is to provide a set of automated tools for detailed transportation
analysis that will also furnish deployment data to support combat simulation
models. CAA has published GDAS requirements in a report entitled "Strategic
Transportation Analytical Requirements (STARS): Functional Description of a
Global Deployment Analysis System." Ultimately, the intended larger system of
which the GDAS is a part will simulate the mobilization of U.S. forces,
deployment of forces and supplies across an inter-theater network, and onward
deployment of forces and supplies to the combat zone.

Potomac Systems Engineering, Inc. (PSE), provides IV&V support to CAA during
the GDAS development project. Development of the GDAS is a 24-month effort,
executed in three phases. Phase I (design) was a 9-month study in which the
model developers detailed their specific approach to the design of the system.
It included recommendations for specific hardware and software to be used in
implementing the system and developing a prototype model that contains
specific features planned for inclusion in the final GDAS model. During phase

II (implementation), the developers are implementing the functional input and output data bases for the GDAS data base management system (DBMS) on CAA equipment, and will code and implement prototypes of the system modules. In phase III (integration, training, and testing), the developers will fully integrate the DBMS and system modules, implement the entire system on CAA equipment, and train CAA personnel on operation and maintenance of the system.

1.2 Purpose

This Independent Verification and Validation (IV&V) Management Plan (IVVMP) describes the IV&V services that PSE will provide to support CAA's Special Assistant for Model Validation during the GDAS development project. The project is intended to result in a fully integrated software system to support combat analyses by providing combat simulation models with detailed force and resupply buildup schedules and to perform detailed inter-theater transportation analyses.

1.3 Scope

The IV&V tasks described in this IVVMP update are outlined in Delivery Order 0005, GDAS IV&V-II. The initial GDAS IVVMP (10 November 1989) and its first update (23 March 1990) addressed tasks accomplished by PSE during the design phase (phase I) of the GDAS development project, as specified by the government in Delivery Order 0001. Some of the IVV&A activities in this update began in the design phase and will continue throughout the model's development. Others are keyed to the GDAS implementation activities anticipated in phase II. Specific details of activities and schedules beyond the scope of the existing Delivery Order (extending past the period of performance) will be established in the Delivery Order for phase III. The IVVMP will be updated accordingly.

SECTION 2. IVV&A OBJECTIVES AND ADMINISTRATION

2.1 IVV&A Objectives

Experience has demonstrated that problems discovered late in a program, such as during the software integration and test phase, are very expensive to correct. PSE will help the government identify and resolve potential problems as early as possible to minimize the cost and scheduling impact on the program. Many problems can be averted through independent evaluation of the development specifications. Others can be prevented by objective analysis of high-risk areas to help the government determine if the solutions proposed by the software development contractor are adequate and cost-effective. Independent monitoring of the development process also helps to identify hardware and software inconsistencies as they occur, thus minimizing the time and resources expended in correcting such inconsistencies.

Verification is the process of determining that a model represents its conceptual description and specifications. During the development of a model, verification is best accomplished by establishing that the system meets all of its documented system requirements. When prototypes are used in the development of a model, the operation of key functional algorithms can also be verified by running limited sensitivity analysis. It is a continuing effort that reveals errors, omissions, and potential hazards early in the development process when errors are less expensive to correct. Verification involves evaluation and analysis to determine model consistency, completeness, and adequacy at each level of development as well as traceability of requirements to the previous level in the development cycle.

Validation is the process of determining that a model adequately represents the intended system. During the development of a model, validation is best accomplished by establishing that the system achieves its specified functional and performance levels from the subsystem level to the fully integrated system in a reliable and efficient manner. This may include comparing results from separable modules or from the overall model with those from real-world entities, other verified and validated models, test and exercise data, or historical observations.

PSE's IV&V objectives during the GDAS implementation phase (phase II) are as follows:

- o Update the IVVMP as required
- o Verify and validate GDAS prototypes
- o Review GDAS documentation produced by the model developer
- o Support and participate in GDAS program reviews
- o Track GDAS developmental activities.

At the conclusion of the GDAS development project, PSE will provide to the government the final version of this IVVMP, including all quarterly updates. In addition, PSE will provide a final report summarizing all IVV&A activities and accomplishments supporting this project and recommending procedures for

the life cycle maintenance and testing of the GDAS software to assure its continuing validity and credibility in support of the Army study program.

2.2 IVV&A Administration

2.2.1 Schedules and Deliverables. The Delivery Order for the GDAS IV&V project describes the schedule to accomplish each of its defined tasks. Specific dates for reports and deliverables are listed in table 2-1. The Gantt chart in figure 2-1 provides an overview of the planned start, finish, and interim deliverable dates for GDAS phase II IV&V. Phase III will be initiated by a separate Delivery Order. Activities that will be scheduled by the government are indicated on the dates anticipated by PSE. Changes in the dates of these activities may require dates for subsequent activities to be adjusted. PSE feedback on GDAS program reviews, for example, is provided to the government no later than five working days after each review.

Table 2-1. Reports and Other Deliverables

NUMBER	DELIVERABLE	DUE DATE
0002AA	Conference of Contractor and COR	10 Days ATA*
0002AG	Draft IV&V Management Plan	30 Days After Initial Conf.
	Final Report	15 Days Prior To Contract Completion
	*ATA - After Contract Award	

Figure 2-2 is an example of the detailed work plan used during GDAS phase I IV&V to map a programmed sequence of GDAS prototype runs over a forseeable period of time. A similar work plan will be used for operation of GDAS prototypes during phase II, but no prototype is currently available for IV&V runs. PSE is awaiting information on the features and projected availability of the next GDAS prototype to plan the next series of runs. The detailed work plan will be continually updated with the COR to remain in step with model development activities, but minor changes in the work plan will not be considered sufficient cause to update the IVVMP. Necessary IVVMP updates will be coordinated with the COR.

Schedule Name: GDAS Phase II IV&V
Project Manager: Vernon M. Bettencourt
As of date: 6 July 1990

```
                                                   90                        91
                                         Jun Jul Aug SepOct Nov Dec Jan Feb Mar Apr May Jun
                                Status    1   2   1   4  1   3   2   1   1   1   1   1   3

Initial Conference with COR       D     +
IV&V Management Plan              D     +++++
Verify/Validate GDAS Prototype          ++++++==================================
Review GDAS Documentation                ++++++=================================
Support Jul Program Review                         ==
Track Development Activities                       .+++===============================
Support Sep Program Review                                ==
Support Dec Program Review                                        ==
Support Mar Program Review                                                    ==
Final Report                      C                                              =====
```

D Done   ━━━ Task   - Slack time (═══--), or
C Critical   +++ Started task   Resource delay (-·-═══)
R Resource conflict M Milestone   > Conflict
p Partial dependency
Scale: Each character equals 1 week

                  Figure 2-1.   GDAS Phase II Planned IV&V Activities

ACTIVITY	MARCH 1990			
	5	12	19	26
Analyze GDAS Design Specification				
Feedback on GDAS IPR				
Run GDAS Prototype:				
Query Input Data	X X			
Run & Change a Scenario		X X		
Query & Graph Output			X X	
Vary Cost Functions				X X

ACTIVITY	APRIL 1990			
	2	9	16	23
Run GDAS Prototype:				
Compare Convoy vs. Independent Movements	X X			
Investigate Results of Attrition		X X	X X	

Figure 2-2.   Detailed GDAS IV&V Work Plan (Sample)

2.2.2 **Resources**. The PSE resources to support GDAS IV&V activities include a highly experienced analyst performing technical and management duties and another highly experienced analyst providing technical support and peer review of results as required. The COR will be notified in advance of all technical personnel providing support for this project. Secretarial services, editing, and graphics will be provided by support personnel.

SECTION 3. VERIFICATION, VALIDATION, AND ACCREDITATION

3.1 Task Descriptions

The general task established by the Delivery Order for this project is to
provide CAA independent verification and validation services in support of
phase II (12 months in duration) of the development of the GDAS. The total
project is intended to result in a fully integrated software system, which
will support combat analyses by providing combat simulation models with
detailed force and resupply buildup schedules and will perform detailed inter-
theater transportation analyses. This section describes in detail PSE's
approach for performing the IV&V tasks specified in the Delivery Order. (No
accreditation task was specified by the government for this project.)

Beyond this update of the IVVMP, there are four tasks:

    o   Verify and validate GDAS prototypes
    o   Review GDAS documentation produced by the model developer
    o   Support and participate in GDAS program reviews
    o   Track GDAS developmental activities.

These will be referred to as Tasks 2 through 5, respectively, as listed in
PSE's technical proposal responding to the Delivery Order.

3.1.1 Task 1 - Independent Verification and Validation Management Plan. The
first task provides for periodic updates of this management plan as required
by changes in the GDAS development schedule.

3.1.2 Task 2 - Independent Verification and Validation of GDAS Prototypes.
The GDAS development schedule has evolved to use several iterations of
prototype models, which progressively incorporate more of the features
intended for the final GDAS system. IV&V procedures for this task were
revised to help the government assess the model developer's quality assurance
(QA) and configuration management (CM) activities by exercising and evaluating
the capabilities of each prototype. This IV&V approach has the additional
advantage of providing the government accurate feedback on the performance of
GDAS algorithms early in the model's development rather than waiting until the
formal tests for model acceptance. PSE activity on this task began in
February 1990 and will continue throughout the GDAS development process.

The exact IV&V procedures to be used at a particular stage in the GDAS
development will be determined in coordination with the COR. This will be an
iterative process requiring frequent interaction with government personnel.
For the evaluation of a particular prototype model, it will be necessary to:

    o   Identify the features of the prototype that are newly added and
          those that were corrected from an earlier version to determine
          what tests can be performed
    o   Prioritize the list of features and tests so that available IV&V
          resources can be allocated primarily to the most significant tests

o   Schedule a series of model runs to assure the availability of personnel, equipment, and data for specific events

o   Exercise the model at each session to observe and assess the functions identified for examination in that session

o   Record the results of the session with comments on the functions exercised and any model deficiencies or discrepancies noted

o   Periodically update the planned run schedule to provide for retesting or additional tests based on the results of previous sessions

o   Perform literature searches or hold discussions with government experts to resolve questions or issues related to the desired performance of GDAS.

All of these procedures may be executed for particular IV&V events, while subsets of these procedures may be selected by the government for some IV&V events to obtain the greatest possible benefits within the agreed-upon level of effort under this contract.

The GDAS Test Observation form shown in figure 3-1 was developed by PSE as a vehicle for effective communication among IV&V analysts, government personnel, and the model developers on the results of running GDAS prototypes. Before being put into use, the form was reviewed for relevance by both the government and the model developer, and their suggestions were incorporated. The form was used successfully by PSE personnel, government personnel, and model development personnel to document results during GDAS Phase II IV&V operations with model prototypes.

At least one form is completed for each trial attempted in the run sessions to reflect successful completion or failure of the event. The forms are numbered sequentially and a copy of each completed form is maintained in a package controlled by the COTR for the GDAS development project. A block at the bottom of the form marked "for CAA use" provides space to note plans for additional work related to each event.

Detailed planning schedules for GDAS prototype run sessions and related events are prepared monthly and cover a period of two months. A 2-month planning cycle provides a sufficient horizon to incorporate significant events in an organized fashion, and monthly updates ensure a focus on current activities. These schedules are reviewed with the COR as often as necessary to coordinate changes due to intervening events. An example of a detailed planning schedule is shown in figure 2-2.

One important concept to be addressed here is that preparation for software support must occur during software development. The GDAS system is planned for a 10-year life cycle. During that time, it may be continually revised to correct problems, to respond to changing requirements, and to adapt to new equipment. The iterative prototyping approach adopted for the development of GDAS should provide opportunities for the government to nominate various

3-2

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+------------------------------------------------------------------+
|                  POTOMAC SYSTEMS ENGINEERING                     |
|                    GDAS Test Observation                        |
+------------------------------------------------------------------+
|                                                                  |
|  Item number:                      Analyst:                     |
|                                                                  |
|  Date:                             Phone:                       |
|                                                                  |
|  Model Component:                                               |
|                                                                  |
|      ___ Input Data    ___ Model    ___ Results    ___ Utility  |
+------------------------------------------------------------------+
|  Summary of Observation:                                        |
|                                                                  |
|                                                                  |
+------------------------------------------------------------------+
|  Complete Description:                                          |
|                                                                  |
|                                                                  |
|                                                                  |
|                                                                  |
|                                                                  |
|                                                                  |
|                                                                  |
|                                                                  |
+------------------------------------------------------------------+
|                         For CAA Use                             |
|                                                                  |
|  Plan Followup?         Review Date:           Priority:        |
|                                                                  |
|  Comment:                                                       |
|                                                                  |
+------------------------------------------------------------------+
```

PSE Form #94

Figure 3-1. GDAS Test Observation Form

3-3

changes to the model based on IV&V results and to evaluate the ease or difficulty involved in implementing those changes. This process can also help the government to identify what elements of the contractor's software engineering environment and software test environment need to be designated as deliverables for adequate life cycle software support within CAA.

3.1.3 <u>Task 3 - Review GDAS Documentation</u>. PSE will review documents generated by the GDAS model developers to assess whether each document is technically correct and consistent with other related GDAS documents. PSE anticipates that the following documents will be provided by the GDAS developers in formats consistent with DoD-STD-7935A:

     o   System Test Plan
     o   System Test Analysis Report
     o   User's Manual
     o   Program Maintenance Manual.

Each of these documents will be evaluated for its compliance with the format and content specified by the government. PSE will coordinate with the COR to obtain the following documents needed to perform the document review:

     o   Document to be reviewed
     o   Applicable development contract provisions (e.g., SOW)
     o   Applicable DoD standards and associated documentation
     o   Review criteria unique to the document
     o   Previous review reports.

Deviations, errors, and/or ambiguities in format and content will be reported to the government with recommended corrective actions.

3.1.4 <u>Task 4 - Support and Participate in GDAS Program Reviews</u>. PSE continues to support the government by participating in all GDAS system reviews, including the Preliminary Design Review, Critical Design Review, In-Progress Reviews, and Analysis Review Boards scheduled by the government. PSE has been advised by the government that the contractor developing the GDAS will provide the following information at each review:

     o   Summary of work done in the current phase, including refinements to the functional description as further defined by the contractor and COR for GDAS development

     o   Major tasks accomplished to date and projected through the next reporting period

     o   Detailed descriptions of current and projected problem areas, if any, and approaches to solving them

     o   Validation and verification plans and progress during the previous period.

PSE independently evaluates such information as provided by the government or as presented at a system review. Within five working days after participating in each system review, PSE provides to the government feedback on discrepancies, shortfalls, or issues resulting from the review that may impact the quality of the GDAS model development.

3.1.5 <u>Task 5 - Track GDAS Developmental Activities</u>. PSE keeps abreast of current and projected GDAS development activities to facilitate responsive planning of IV&V activities. The current allocation of resources to this task limits the level of effort to that required for efficient planning of IV&V activities. This action tracking activity could be expanded by allocation of additional resources to provide the government an automated capability to track GDAS action items and generate up-to-date status reports on demand. In coordination with the COR, PSE could establish an action tracking data base which would enable PSE analysts to link action items specified by the government or resulting from GDAS system reviews with related model development or IV&V actions and milestcnes. The action tracking data base would allow the government to quickly obtain the status and history of any GDAS development activities maintained in the data base.

The content and format of program status information contained in the action tracking data base will be coordinated with the COR to ensure that customized reports can be drawn from the data base quickly and efficiently. Activity reports from the model developer and minutes of GDAS system reviews can be "marked up" by government personnel, with references to applicable requirements or specifications in the baseline data base, to indicate action items that PSE will enter into the action tracking data base.

Customized reports can then be developed based on the information entered into the data base and on the requirement for an update. As an example, a list of open action items could be prepared for a GDAS In-Progress Review. Each open action item could be reported with its date of origination, latest reported status, and references to the baseline GDAS requirements identified with the action item. In addition, the update report format could provide space for notes so that the report itself could be used both as a reference during the review and as a source document to update the status of each action item in the action tracking data base.

3.2 <u>Final Report</u>

At the conclusion of the GDAS development project, PSE will provide to the government a final report summarizing all activities and accomplishments of the GDAS IV&V effort. The report will also include recommended procedures for life cycle maintenance and testing to continue the validity and credibility of GDAS in support of the Army study program. With a newly developed model, for example, it is a sound practice to perform independent verification and validation (or accreditation) using a "shakedown" study with actual data representative of a typical study scenario. If at all possible, the shakedown study should parallel a previous study done with a similar, accepted model to compare both the model output and the final results of the analyses.

A draft of the final IV&V report on the GDAS model development will be submitted 15 days before the end of the IV&V tasking for government review and comment. The final version of the report will be planned for completion on the last day of the IV&V task period if no adjustments are required to accommodate government requests for changes. Necessary adjustments will be coordinated with the COR if feasible within the remaining project resources.